The conservation status of Echo Parakeet *Psittacula eques* of Mauritius

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Introduction and background

On human colonisation of Mauritius, three endemic species of parrot were noted: *Lophopsittacus mauritiana* a large, crested and heavy beaked grey parrot that became extinct around 1680, *Lophopsittacus bensoni* a smaller grey parrot that became extinct in the 1760s, and the still extant Echo Parakeet *Psittacula eques*[1].

The Echo Parakeet is a medium-sized parakeet weighing 130–190 g. It is similar in size to the introduced Ring-necked Parakeet *Psittacula krameri* but is heavier, more solid in appearance and the tail is almost equal in length to the body. Echo Parakeets are also a darker green colour, have lower pitched calls, slower flight, and females have a dark beak. It has been treated as a subspecies of Ring-necked Parakeet but was considered specifically distinct by Jones[4]. This separation appears to be valid based on ecological observations and breeding biology. An investigation into the evolutionary divergence of the Indian Ocean *Psittacula* species is underway (J Groombridge pers. comm.).

Echo Parakeets are herbivorous, eating fruit, flowers, leaves, buds and bark of a wide range of species. They forage widely and target different plant species at certain times of the year[5].

Nests are in cavities of emergent endemic trees. The clutch size is normally 2–3 eggs (range 1–4) which are laid from September–December. Eggs are laid at two-day intervals. Incubation starts with the first, or sometimes second, egg and lasts 21–25 days. Only females incubate. Chicks weigh between 8.5–11 g upon hatching and grow quickly, peaking at around 170 g before fledging at c150 g, 53–63 days after they hatch. Two young is the maximum number known to fledge from a nest.

Black River Gorges National Park, Mauritius, January 1997 (Robert Lucking)

Juvenile Echo Parakeet *Psittacula eques*, Mauritius, January 1997 (Robert Lucking)

Echo Parakeets were formerly common on Mauritius but began to decline in numbers and range in the mid-1800s, until by 1986 the population was estimated at only 8–12 individuals[5,6]. They are now only found in c50 km^2 of remnant native upland forest[6]. This area is contained within the 7,000 ha Black River Gorges National Park created in 1993. No Echo Parakeets are present in any other area of Mauritius.

Only 1.27% of Mauritius' native forest remains[3]. This forest, which the Echo Parakeet inhabits, continues to be highly degraded by cyclones, the influence of past forestry practices and by the spread of exotic plants especially Guava *Psidium cattleianum*, Privet *Ligustrum robustum* and Jamrosa *Syzygium jambos*[1,2,5,6]. Many alien feral mammals are present including Ship Rat *Rattus rattus* and Norway Rat *Rattus norvegicus*, Macaque Monkeys *Macaca*

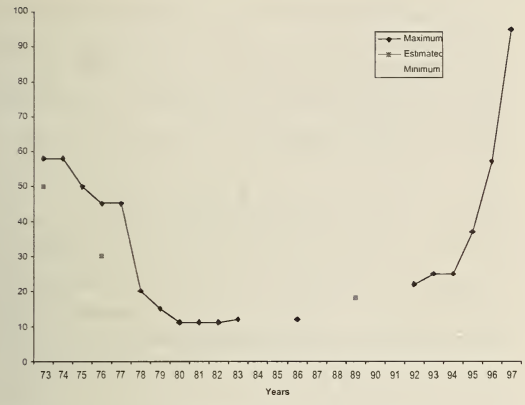

Fig. 1. Echo Parakeet *Psittacula eques* population trend[5,7,8,11,12].

fascicularis, domestic Cats *Felis cattus*, Mongooses *Herpestes auropunctatus*, Pigs *Sus scrofa* and Rusa Deer *Cervus timorensis*, which have a significant negative effect on indigenous flora and fauna[1,5,6]. Introduced Common Myna *Acridotheres tristis* and Ring-necked Parakeet are nest site competitors with the Echo Parakeet[4].

The decline of the Echo Parakeet has been attributed to habitat destruction and degradation, exotic predators, competition for nest cavities, seasonal food shortages, nest fly infestations and genetic/demographic reasons[5,6].

Conservation efforts to recover the Echo Parakeet were initiated by the Mauritian Wildlife Foundation in 1973 and intensified in 1987. Many techniques have been used including habitat protection and improvement (fenced and weeded forest plots), rat control around nest sites, manipulation of nests, supplementary feeding and provision of nest boxes[6].

Between 1993–1995, the programme was further refined and current efforts are based on this methodology. The main emphasis is now on predator control, nest cavity improvement, clutch manipulations and daily examination of active nests. As a result, Echo Parakeet is one of the most intensively managed avian species in the world.

Since the 1994–95 breeding season the minimum Echo Parakeet population has been increasing rapidly (by 47% in 1994–95, 47% in 1995–96, and 68% in 1996–97). At the end of the 1996–97 breeding season the total population was 84–95 individuals[12]. Forty chicks have now fledged from wild eggs in the past three breeding seasons. However, only 12 of these have fledged into the wild. The following is a more focused examination of the current threats to the Echo Parakeet and current conservation methodology.

Population growth

The total Echo Parakeet population has grown quickly over the past three breeding seasons. A major reason for this is the intensive management programme.

The discovery of new breeding groups in recent years has also raised the population total. Some of these were almost certainly present in previous years but without intensive searching remained undetected.

A change in the proportion of breeding groups that attempt to breed each year has also played a role in the population increase. For the period 1973–1994 only 42–60% of the known breeding groups attempted to breed. Over the last three breeding seasons this figure has risen to 92%. The reason for the increase in breeding attempts is unknown. Current management techniques do not include methods for increasing the proportion of breeding groups. An increase in available food supply due to increasing utilisation of exotic species may be the answer. Prior to the 1994–95 breeding season exotic species comprised very few of feeding observations (4%[5], 3% in 1993–94[7]). This contrasts with 26% in 1995–96[11], and 31% in 1996–97[12]. Particularly important could be the exceedingly common Guava which can fruit very heavily in July–

Table 1. Wild Echo Parakeet *Psittacula eques* breeding summary since 1973[5,6,8,11,12]

Year	Number of known breeding groups	Number of groups laying eggs	Number of groups fledging young successfully	Number of young fledged
1973	-	7 (11)	2 (7)	2–4 (11)
1974	-11	-7	6 (4)	11 (5)
1975	-	6 (6)	1 (2)	2 (4)
1976	6–11 (-)	- (-)	3 (0)	5 (0)
1977	-	-	-	-
1978	3	1	0	0
1979	3	0	0	0
1980	2	1	0	0
1981	2	1	0	0
1982	1	0	0	0
1983	1–2	0	0	0
1987–88*	4	1	1	5
1988–89	4	1	0	0
1989–90*	4	2	2	5
1990–91*	4	3	2	5
1991–92*	4	3	3	7
1992–93*	5	2	1	4
1993–94	5	3	0	0
1994–95*	6	6	4	8
1995–96*	7	6	5	11
1996–97*	13	12	10	21

* Figures include wild eggs and nestlings harvested and reared in captivity.

( ) a second estimate for the season.

September, when breeding initiation probably occurs in Echo Parakeets. A grove of introduced Starfruit *Averrhoa carambola* trees is much-utilised by Echo Parakeets from January–March[13]. This use of exotic food sources is a promising sign in that it could release Echo Parakeets from one of their major constraints—food shortage due to habitat deterioration. Rejuvenation of the breeding population by recruitment of young birds could also have increased the breeding proportion.

The role of food supplies

Seasonal food shortages have often been discussed as one of the reasons for the Echo Parakeet's rarity[5,6]. Results from the past four breeding seasons suggest food shortage as the major cause of nest failure within the management programme. During successful breeding seasons, eg 1994–95, most breeding groups, managed or not, can successfully fledge young, but during 'normal' breeding seasons most nests fail or are only able to fledge a reduced number of young.

The reason for this food shortage is deterioration of the native forest. All areas where Echo Parakeets now breed contain only patches of native vegetation in a sea of Guava and Privet. While these exotics can provide a very abundant food source it is not available year-round or even throughout the breeding season. Normal fruiting levels of native species are patchy in distribution and frequency with only some species fruiting each year. This is demonstrated by the little overlap in native species recorded in feeding observations from breeding season to breeding season. Macaques also strip much of the fruit from trees, often before it ripens.

Cyclones can stimulate the native vegetation to fruit abundantly the following year, which increases breeding success

Supplementary feeding

Supplementary feeding can be very useful in removing food limitations on breeding output. Most conservation programmes with a supplementary feeding component report an increase in breeding attempts (eg Kakapo *Strigops habroptilus*[10], Seychelles Magpie-Robin *Copsychus sechellarum* (R Lucking pers. comm.) and of course the Mauritius Pink Pigeon *Nesoenas mayeri* and Mauritius Kestrel *Falco punctatus* (CJ pers. obs.). Supplementary feeding programmes have to be designed intelligently and monitored closely to avoid problems such as infertility, female burn-out and an increased disease risk, which are concerns held by some wildlife managers. Attempts continue to introduce wild adults to supplementary food but with little success to date. Released captive-reared juveniles are trained to use supplementary food provided in parrot feeders—as used on the Kakapo project—which exclude other bird species and rats.

Clutch manipulations and rescues

As part of the management programme, the first clutches of selected breeding groups are harvested to increase productivity via double clutching. Fostering of eggs and nestlings is also utilised to spread risks and circumvent parenting problems. Rescuing of at risk clutches and starving nestlings is very successful at maintaining productivity. This is an essential technique in years of poor food availability or adverse weather. Daily inspection of nestlings allows problems to be detected early and remedied. Harvesting eggs and rescuing clutches over the past three years has bolstered the captive population at the Gerald Durrell Endemic Wildlife Sanctuary (GDEWS).

Management of nest cavities

Nest linings consisting of wood-shavings treated with a fungicide and insecticide are used in all accessible nest cavities. This has been very effective in that no nests are known to have failed due to nest-fly or fungal infestations in the past three seasons. In the 1993–94 season nest-fly predation was responsible for one of three nest failures. Aspergillosus infection has been noted as a cause of nest failure at GDEWS in the past[8].

Many of the cavities used by Echo Parakeets are becoming old and unusable. There may be a lack of alternative cavities due to the limited numbers of mature cavity bearing trees in the highly degraded forest. Competition also exists for cavities (see Cavity competition). Weatherproofing and cavity maintenance are ongoing activities.

Cavity competition

Competition for nest cavities appears high with 14–19% of Echo Parakeet nest cavities lost to competitors each year[12]. The main culprits are (in order of importance): Ring-necked Parakeet, Common Myna, White-tailed Tropicbird *Phaethon lepturus* and bees. Not included in the above figures are take-overs of cavities not actively in use or between breeding seasons. Termites and rats have been responsible for the former. Other potential nest competitors are wasps and Mauritius Kestrels.

Cavity loss due to cyclones and general deterioration due to age also takes its toll. Jones & Duffy[6] found

a loss of 18% per cavity year. Cavity maintenance as part of the management programme probably slows the rate of cavity loss due to deterioration as no cavities have been lost since the 1993–94 season. Two cavities (3.4% per cavity year) are known to have been lost in cyclones since 1987[6,8]. Temple (in Jones & Duffy[6]) describes nine of 23 (38%) cavities being destroyed in a cyclone in 1975.

Cavity competition may not yet be a limiting factor for the Echo Parakeet population as all known breeding groups are in possession of a cavity. If pressure to find breeding sites existed then some of the 57 nest boxes installed since 1974 should have been used, but none has yet been used by the species (pers. obs.). As the Echo Parakeet population increases, competition for nest sites will probably increase.

Rodent control

The large number of rats present in the Mauritian forests will both predate eggs and nestlings and compete with Echo Parakeets for the limited food supplies available. Current efforts to control rats around nest sites centre on two techniques: a 200 m^2 poison grid centred on the nest site, or surrounding the cavity entrance with physically insurmountable PVC sheeting. The latter technique is still being developed and needs special care to be effective.

Capture and banding

Capture of adult birds in the nest cavity as a technique has allowed the ringing of adults as well as fledged juveniles. The ringing programme has been invaluable in determining movements and breeding success of individuals and nest site occupation.

Mortality and sex ratio of wild birds

Mortality of adult Echo Parakeets is very low. Only 4.2% per annum of banded females and no banded males have died, although these figures originate from a very small sample[12]. Jones & Duffy[6] also note higher mortality in females. This differential mortality if carried over several years could result in the bias of two males for every female in the population.

Juvenile mortality appears to be c20% per annum[12]. However, this has again been computed from a very small sample. There are no documented causes of mortality of adult birds. Jones[5] postulates direct (through destruction of birds in cavities) and indirect (starvation due to lowered food supply) cyclone-related mortality. A macaque has been observed carrying an adult Ring-necked Parakeet (S Roy pers. comm.).

Known causes of mortality of nestlings include ten instances of starvation, three instances each of disease, nest-fly parasitism, cavity take-over, desertion, and one instance each of drowning during a cyclone and growth abnormality[12].

The role of surplus males

Most breeding groups have 1–3 'surplus' males in attendance. Debate continues as to whether these extra males are 'helpers' or 'hinderers'. At the start of nesting, subdominant males are usually chased off by the dominant male or the female. As the season progresses and the parents are absent for longer periods of time, some of the extra males enter the nest cavity and feed the nestlings. Occasionally extra males are also known to feed the incubating female if the dominant male is absent. These extra feedings probably benefit both the female and the nestlings. However wild fledging success appears to be independent of group size and may in fact be more closely related to the dominant male's experience.

Some examples of hindrance are documented. Jones[5] quotes an instance when a male replaced the dominant male at a nest which then failed a week or so later. In the 1994–95 season, two newly hatched nestlings were found with their heads crushed either by an extra male or by Common Mynas (which were nesting 1 m below the cavity)[8].

With only two recorded instances of hindrance the balance strongly favours surplus males being beneficial or neutral.

Surplus males at nests may be a recent phenomenon as it was not observed by F Staub in the 1960s or in two nests in 1971, but it was recorded by S Temple in the 1974 breeding season[5]. Jones[5] theorised that it was due either to the skewed sex ratio towards males or to non-breeding birds displaced by forest clearance. A skewed sex ratio probably encourages males to join a breeding group where they have a chance of securing either copulations or a mate by displacing the dominant male. Such displacement was observed in the 1995–96 season when the dominant male from a breeding group was held in captivity overnight. Before it was released the next day the other male had started attending and feeding the female. Once the male was released the normal dominance hierarchy was re-established[11].

How the presence of the extra males is translated to helping behaviour such as feeding the nestling (feeding the female could be explained as a displaced courtship ritual) is unknown. Perhaps the males are simply responding to begging stimuli while hormone levels are high.

Disease and inbreeding

Disease screening shows that diseases are either prevalent throughout the population (Polyoma Virus and Herpes Virus) or are entirely absent (Psittacene beak and feather disease, blood parasites) (A Greenwood pers. comm.). There is little evidence to date of inbreeding and fertility is 96%[9], but the occurrence of a soft bone condition in some nestlings could be due to inbreeding.

Releases of captive birds

The first release into the wild of three captive-reared Echo Parakeets successfully occurred in July 1997[9]. Most captive-reared individuals from eggs and nestlings removed from wild nests, supplemented by captive-bred individuals, will be released. These birds are taught to use supplementary feeding stations and nest boxes. It is hoped that they will in turn train wild individuals to use these by association.

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